Printed and Digital Media: Printed and Digital Textbooks

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∼ This paper aims to sketch a framework for comparing the efficiency of printed and digital textbooks. Considering the fact that digital textbooks are a relatively new phenomenon, they lack both practical experiences with their use, and research on their efficiency - which is why all results will only be of a preliminary nature. This is also why our paper will focus on an initial definition of not only the theoretical framework for analysing the nature of digital media, but also for analysing printed and digital textbooks. The broadest theoretical framework consists of Lev Vygotsky's theory on the character of culturally-psychological tools and their influence on the functional organisation of the brain and of Marshall McLuhan's theory of media, concerning the general fact of the medium (and not its content). The theoretical analysis shows that media (printed and digital) have significant impacts on the functional organisation of the brain, which is based on the brain's neuroplasticity. The analysis of digital media shows that they possess a set of specific features that, despite all the advantages they have, carry important risks for the organisation and functioning of the brain and for the process of learning. The production of digital textbooks also faces a significant number of challenges that the current production has not yet solved. Empirical research on the process of digital reading and understanding what has been read, indicate all the problems that still exist in digital textbook creation.

Keywords: digital and printed media, impact of digital media, comparison of digital and printed textbooks, educational effects of printed and digital textbooks

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Tiskani in digitalni mediji: tiskani in digitalni učbeniki

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Namen prispevka je skicirati okvir za primerjavo učinkovitosti tiskanih in digitalnih učbenikov. Glede na to, da so digitalni učbeniki razmeroma nov pojav, trenutno še nimamo ne praktičnih izkušenj z njihovo uporabo ne raziskav o njihovi učinkovitosti, zato so vse ugotovitve samo preliminarne. Naše delo se zato osredinja na začetno opredeljevanje teoretskega okvira za analizo narave digitalnih medijev ter vzporedno analizo tiskanih in digitalnih učbenikov. Najširši okvir teoretične analize predstavljata teorija Leva Vigotskega o značaju kulturno-psiholoških orodij in njihovega vpliva na funkcionalno organizacijo človeških možganov ter teorija medijev Marshalla McLuhana, ki zadeva splošno dejstvo medija (ne pa tudi njegove vsebine). Teoretična analiza je pokazala, da imajo mediji (tiskani in digitalni) pomemben učinek na funkcionalno organizacijo možganov, ki sloni na njihovi nevroplastičnosti. Analiza digitalnih medijev kaže, da imajo ti vrsto specifičnih značilnosti, ki – ob vseh prednosti, ki jih ta medij sicer ima – prinašajo precejšnja tveganja za organizacijo in funkcioniranje možganov ter za proces učenja. V tem okviru se tudi ustvarjanje digitalnih učbenikov srečuje s številnimi izzivi, ki v današnji produkciji digitalnih učbenikov še niso razrešeni. Empirične raziskave procesov digitalnega branja in razumevanja prebranega kažejo na vse težave, s katerimi se še vedno srečujemo pri ustvarjanju digitalnih učbenikov.

Ključne besede: digitalni in tiskani mediji, vpliv digitalnih medijev, primerjava digitalnih in tiskanih učbenikov, edukacijski učinki tiskanih in digitalnih učbenikov

Introduction

Despite differences in dynamics, all countries in the world are facing the beginning of the era of publishing digital (electronic) textbooks: some countries (Serbia among them) are only starting this process and some are already quite ahead (for example South Korea, which came to the decision years ago that they would completely switch to publishing digital textbooks only in 2015).

Parallel to this, all countries also witness contradictory attitudes regarding the value of digital textbooks, arising from the public, including the educational public (alongside the usual silent majority that is indifferent to this innovation). One type of reaction could be called »affinity for novelties« and it consists of an attitude that everything new is also good and should be embraced (sometimes with enthusiasm and excessive expectations). The other type of reaction is completely opposite to the one just mentioned and consists of a conservative attitude of rejection, often to all that is new.

However, as many authors, even those that are sceptical about digital textbooks (and electronic books generally), have noted, digital textbooks and digital media generally are already a reality and will appear more and more often on the market of school books. The true problem lies in determining the meaning of this novelty, which has to be constructed neutrally, without passionate cheering and without the pressure from the manufacturers of electronic devices (that aim to make a profit and therefore have an interest in an accelerated digitalisation of the educational field that should be implemented at all costs). What is necessary is to rationally examine and question this novelty with a serious, scientific approach based on all available knowledge and insights.

The problem of digital textbooks has to be considered as part of a broader perspective. Namely, digital textbooks are only one phenomena of a broader historical change – **the digital revolution**. We are truly faced with a revolution, the potential effects of which at least equal the revolution caused by literacy (which underlies our division of the past on pre-history and history) and the industrial revolution. As any true revolution does, the digital revolution touches upon all spheres of life (economy, society, education, science, art). A crucial factor for the issues we are concerned with in this paper is that this is a true **intellectual** revolution, since it changes the intellectual components of all human activity and this has specific consequences for activities such as learning (education), where the intellectual component comprises the essence of the activity itself.

Due to the fact that the digital revolution as well as digitalisation in the field of education (digital learning, digital classrooms, digital textbooks,

electronic diaries) are new phenomena, the basic goal of this paper is to find answers to the following questions: what are the possible positive and negative consequences and effects of such major changes; how can historical experiences with past revolutions help us to understand the meaning of this new revolution; what do these changes mean not just for education and the process of learning but also for the functioning and development of the individual (his/her intellectual, social and emotional development and their cognitive functioning); what are the effects that relate to intellectual efficiency; what consequences do exposure to the digital world and virtual reality have on the functioning of the human brain; how can we efficiently use our knowledge about the effects of printed textbooks to better understand the difference between them and the new digital textbooks?

What is important to note at the beginning is that digital textbooks in their different forms are **a new phenomenon,** not only in our country but also in countries that started using them earlier (some states in the USA, South Korea) and **we still do not have enough concrete experience with using these types of textbooks, and even less of rigorous research on their use and the effects they have**. One of the foundations for examining the value of digital textbooks is the existing knowledge and years of experience with the use of traditional, printed textbooks and the extensive research related to them. This paper is based on this knowledge of printed textbooks, that the author of the present paper and a group of his colleagues have gained.[2]

We first need to highlight two fundamental methodological principles that form the basis for comparing printed and digital textbooks: a) we will compare the best versions of printed and digital textbooks, that is the versions that make the most optimal use of the media at hand (printed or digital); b) our comparison will not focus on technical and secondary aspects of textbooks, which we can often find in so much of the literature on the topic (the technical ease of reading, that is navigating through the digital or printed textbook; accessibility of the textbook; the cost of textbooks, including the cost of equipment required for their use; student preferences for one or the other type of textbooks, since all of these will change over time, etc.). The focus of our comparison will thus be on the extent to which digital or printed textbooks contribute to achieving educational outcomes and individual forms of educational

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2   There are a number of works (books, papers, masters and PhD thesis, conference presentations) detailing this research that has begun more than 40 years ago at the Institute for Pschology. Here we will only name one book that contains a synthesis of all the above mentioned work: Ivić, I., Pešikan A. i Antić S. (2008). *Vodič za dobar udžbenik.* Novi Sad: Platoneum and the updated translation in English that was initiated by the Georg Eckert Institut (Leibnitz - Institut fur internationale Schulbuchforschung) in Braunschweig, Germany: Ivić, I., Pešikan, A., & Antić, S. (2013). *Textbook Quality*. Gotingen: V and R Unipres.

achievements. Bearing the scarcity of existing knowledge in this area in mind – even in the international framework – the results of our comparison can only be preliminary.

Digital and printed media

To understand these issues, we can benefit a great deal by relying on theoretical foundations, above all media theories. In our paper we will rely on theories by the Canadian media theorist Marshall McLuhan (McLuhan, 1971, 1973) and on concepts considering the social-cultural-historical psychology of L. S. Vygotsky.[3] In several of his works Marshall McLuhan has developed a theory that – alongside other strong factors (such as the advancement in techniques and technologies used in human labour) – media (such as for example the emergence of printed books as a new media) have played and still play an enormous role in the development of societies and changes in human behaviour. McLuhan's ideas are specific while they emphasise that the essential part of media is not the **content** that is transmitted but the **nature of the medium** itself. For example, according to McLuhan the crucial point in the emergence of television as a medium is not the content transmitted by television but the nature of television itself that brings a culture of image (instead of a culture of sound and hearing, which dominates in oral speech). The fact that it is a "hot" medium, means that it builds a passive attitude in its consumers etc. At this point it should suffice to remember his famous and often cited thesis that encompasses his other ideas, that is that the "**medium is the message**". We can conclude that this also holds true for digital media.

As for Vygotsky, his ideas, given that they were formulated almost a century ago, today seem prophetic. Vygotsky starts from the fact (confirmed by contemporary evolutionary biology and psychology) that in the last 40.000 years the human brain has not changed morphologically and yet significant changes in human behaviour, such as people's capabilities and achievements, have occurred during this time. This progress is not based on biological (morphological) change, but is based on the development of culturally-psychological tools (the so-called allomorphic development), external aids and amplifiers[4]

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3   This psychological orientation (Vigotski, 1996) develops ideas on the culturally-psychological tools and allomorphic development that enfolds outside the human body as extensions and amplifiers of human capabilities. We would like to emphasise especially the work *The instrumental method in psychology* (Collected works, first edition, p. 82–86, remainding our readers also that the original work dates back to 1934).

4   Althouugh McLuhan did not know the works of Vygotsky and does not refer to him, both use almost identical terms as McLuhans term extension that can be found in the title of his book on understanding media.

of human capabilities, that is, it is based on cultural achievements that serve as an external (inorganic) support for individual human capabilities and as factors of a different functional organisation of the human brain.

In his programmatic text on the instrumental method in psychology, Vygotsky writes:

> Psychological tools are artificial formations. By their nature they are social and not organic or individual devices. They are directed toward the mastery of [mental] processes-one's own or someone else's-just as technical devices are directed toward the mastery of processes of nature. (p. 85)

By being included in the process of behavior, the psychological tool modifies the entire course and structure of mental functions by determining the structure of the new instrumental act, just as the technical tool modifies the process of natural adaptation by determining the form of labor operations. (p. 85)

> *"The application of psychological tools enhances and immensely extends the possibilities of behaviour by making the results of the works of geniuses available to everyone (cf. the history of mathematics and other sciences)".* (p. 87)

The application of these ideas imposes itself on the effects of digital technologies that are a product of culture and that develop as external supports of inner psychic functions that "expand the possibilities of behaviour infinitely" (is the internet not a gigantic extension of human memory, are the gloriously fast computations by big computers, based on a huge number of data, not a strong support for certain forms of human thought etc.). When applied to digital technologies, theoretical conceptions like these can contribute to a better understanding of their nature, their possibilities and – the factor which is extremely important for the issues we are concerned with – their consequences for education, learning, for functional changes in the human brain and thus also for individual development, and even for the fate of man in the future. This is only an indication of some serious general problems that will be further shaped and elaborated in years to come, and serves merely as an initial sketch that is necessary to define the issue of digital textbooks.

Alongside these theoretical bases we will also rely on findings about the general effects of the printed media as an older medium. Unlike the learning of speech (oral speech) that has a significant biological (genetic) basis, the human brain does not have ready-made biological mechanisms for written and printed speech. Written speech is a cultural creation and the brain must functionally organize itself in a new way. That is, the brain must functionally connect different

parts of the brain, such as the area responsible for processing the visual components of language (the graphical image of letters), the area responsible for processing speech sounds, the area for understanding and producing speech etc.

This new functional organisation of the brain is made possible by its neuroplasticity (plasticity of the brain) and leads to what McLuhan has called the »**typographic man**« and Maryanne Wolf (2008; 2016) has called the »**reading brain**«. These terms signify what Vygotsky aimed to prove a long time ago (since he was also concerned with issues of written media), namely that the literate man is not the man who has simply added the capabilities of writing and reading, but is a different man.

The conditions for the development of written speech and the general effects of its emergence have recently been studied in detail. This includes the issue of dyslexia as an inability to learn written speech, and programmes aimed at helping people with dyslexia that are based on creating new functional organisations in the brain with the help of special learning programmes (Dehaene, 2010; Willingham, 2017; Wolf, 2016; Wolf & Stoodley, 2018).

This significant research on **reprogramming** the working of the human brain with the help of media, which is created by culture, have brought about some very important findings: that it is possible for the »old brain« to form entirely new capabilities with the same anatomic characteristics but a different functional organisation of the brain; that it is culture that creates the conditions for such major changes in the organisation of the brain; that this organisation of the brain differs depending on the nature of the language that is acquired (for example, we can find significant differences in the organisation of the brain between people learning Chinese and people learning phonetic languages, that is languages where meaningful units of language can be broken down into sounds – phonemes or graphemes that do not have a meaning in themselves). Significant changes arise precisely with the emergence of phonetic written speech.

There are other, more general effects arising from the emergence of media, such as printed media (the emergence of typography and books): reading takes place in isolation, in quiet, in a process of immersing oneself in the contents of the book while being personally engaged with thoughts and emotions which leads to strengthening the individual and individualism. This in itself leads to enormous social change.

Knowledge on the ways our capabilities for written speech are formed and on the effects of this medium as a new medium (which emerged about 6000 years ago) has led to a crucial finding that **the new media forms are changing the way the human brain function** and can help us to better understand the effects of digital media.

This new mode of organisation of the work of the human brain can occur because of the brain's plasticity (this can be seen, for example, when, due to injuries in some areas of the brain, new areas of the brain - under certain conditions - take over the functions of the injured areas). The latest research on brains elaborates further on what allows for the brain's plasticity (Constandi, 2016). There are several forms of brain plasticity and they depend heavily on age (and on the individual characteristics of every brain). Plasticity is, naturally, greater at a younger age. However, recent research has shown that, contrary to previous, strongly held beliefs, there are nerve stem cells in some parts of the adult human brain and new nerve cells are created. Nonetheless, the basic mechanism of brain plasticity that is directly connected to the issue of digital media, is the mechanism for creating complex synaptic connections (chemical and electrical connections between particular nerve cells) and especially creating different **synaptic circuits** that depend on different life experiences and activity, and on the nature of the media. This is precisely what, according to Vygotsky, changes the course and structure of psychic functions (Vygotsky also uses the term »functional organ«). There are also some significant findings on the shape the organisation of the brain takes when using digital media.

Significant research, authored by a psychologist and a neuroscientist concerns the most common issues regarding the functioning of the brain in a general digital environment (when using television, smartphones, the internet, email, social networks), reading digital texts (digital books, digital newspapers) and indicates all the problems our »ancient brains in a high-tech world« face (Gazzaley & Rosen, 2016, p. xv). There also exists a more popular explanation of these issues in the book by R. Watson (2010), that is also translated into Serbian.

The human species, like all animal species, has an innate need to seek information in its environment, since this represents the condition for its survival. However, in their evolution, human beings did not have experience with such high amounts of information that we have access to in contemporary digital environments, which means that the human brain does not possess innate biological mechanisms of functioning that enable them to deal with this range of information (hence the provocative subtitle of the above-mentioned book – »ancient brains in a high-tech world«). Digital media as new media demands a new organisation of the brain that enables us to cope with, and function in, this new environment. This is possible on the basis of the already mentioned plasticity of the nervous system, especially the brain. This new functional organisation of the brain must be different than the one which was established with the emergence of printed media. However, in the process of building this new functional organisation, the brain is confronted with some serious issues.

Gazzaley and Rosen (2016) sum up the crucial problems posed by digital media in the term **»distracted mind«**. They use it to indicate the basic problems that the »ancient brains« face when in contact with new media. The distracted mind comes to be because, on one hand, the digital environment contains an enormous amount of information but, on the other hand, there is a clear limit to human attention. This results in serious **disturbances** in the reception, selection and processing of information. When receiving information, humans orient themselves with goals that they aim to achieve with the help of this information, but the digital media, constantly bombarding us with information, leads to **the constant distraction of one's attention** (to new information that arrives), to **interruptions** (in the process of monitoring relevant information), to an imposed need to **simultaneously perform several tasks** (multitasking) and to **splitting attention** which causes moving away from the goals of behaviour. To put it in other words, so much »noise« makes it hard to follow the necessary »signal«. Concrete examples from everyday life are when man distances himself from the things that matter to him, can't remember (in terms of long-term memory) what he needs, loses his capability for thinking profoundly, has a hard time making important decisions in business, in his private life or in the process of learning. Examples from the educational field are the disturbances children face when they simultaneously learn and try to follow information on their smartphones (notifications on received messages, reading messages, and exchanges on social media). These problems of the distracted mind are especially serious with certain groups. Examples of these categories of people include: developing children, adolescents, elderly, people with neurological issues. In the last part of the book, the authors describe measures that can contribute to reducing the problems expressed as a distracted mind, among which they also list »traditional education« (Gazzaley & Rosen, 2016).

Concerning the specific aspects of the digital environment, the **reading of digital contents,** and above all, **unrestrained reading on the internet**, some very interesting research already exists. A summarised overview of these results can be found in a well-known book by Nicholas Carr (2013), ***The Shallows: What the internet is doing to our brains***. The subtitle of the book and its contents provide a remarkable demonstration of McLuhan's and Vygotsky's ideas regarding the way in which media, as a cultural creation by its nature, determines the way in which the human brain is organised, the way it functions when using digital media (precisely due to their nature and not their contents), and what general effects all of this has. Namely, Carr (2013) analyses the structural characteristics of media (mostly of the internet). He analyses the characteristics that determine the specificity and essence of digital media. The basic characteristics are

the use of hyper-text or hyper-media (that is, the possibility to pass from one text to another by clicking designated places in the texts, or to pass to another website, dictionary, or an encyclopaedia, or when accessing some inserted multimedia content etc.), which means that there exists a constant connectedness with other sources of information, multimedia (the possibility of turning on audio, image or video inserts while reading the text), interactivity (the possibility that the reader inserts his/her own annotations and notes on which other people can react, commercials, notifications on received electronic messages, and – eventually – after reading these messages, suggestions from the editor or browser). All of these are essential characteristics of digital media and are sometimes remarkable in character (for example, they enable extremely fast access to a large amount of information, easily finding necessary documents or pages in a document, they provide amazing audio or video illustrations). But all of this comes at a price.

Carr (2013) summarises all of these characteristics of digital media or information technologies in a single term, when he calls these technologies **interruption technologies**. Using digital media (e.g. reading on the internet) leads to a set of inevitable effects: an overload of information, attention instability, a big cognitive load when making decisions about which options to use (e.g. hypertext or multimedia attachments), multitasking, frequent shifts of focus, fragmentation of information etc. Even a relatively short process of reading content on the internet (a few days) leads to the creation of new nervous paths and a certain reorganisation of the brain. It is extremely difficult to predict the long-term effects such reading can have on children and young people who are practicing it from a young age.

Carr (2013) summarises the overall effects of digital media use with a term that is also the title of his aforementioned work – **shallow**. In his book, this term has a very profound meaning: after a longer period of reading content on the internet, users of digital sources cannot read longer texts (not even two or three pages of continuous text) because they gain a habit of passing quickly from one piece of information to another, and cannot follow the basic thread (the basic ideas) of a longer text. What is crucial about this rapid jumping from one piece of information to another is that it disrupts a mental process that is extremely important for human memory – the **translation of short-term memory** (the so-called working memory) **into long-term memory.** Short-term memory, if it is not translated into long-term memory, lasts up to thirty seconds and then the information gets lost and is replaced by new information. Long-term memory concerns the true acquisition of experience and knowledge, that can be used in all future activities (sometimes this memory lasts for life). The

process of connecting new information with previous knowledge, which constructs the meaning of new information, unfolds in the long-term memory. This also implies that thought processes are engaged in creating long-term memory.

The mechanism of the brain, that helps creating connections, is the mechanism of creating synapses and synaptic circuits. This process can be understood better if we know that the brain does not have the kind of memory that computers have. That is, it does not have stored and unchangeable information that is recalled and used when needed, like a computer does, and information that has a clear location (although there are people who believe that the brain functions in the same way computers do and that it is just another system for processing information). Contrary to these understandings that identify computers with human brains, long-term memory does not have a »memory« that is located somewhere, or that is fixed and unchangeable. Instead, long-term memory is a dynamic process of forming synaptic circuits that are maintained as long as they are connected and used (reinforced and strengthened with every new use) and are changed as they encounter new information and incorporate it into existing circuits. It is only in this process that isolated bits of information become knowledge. This differentiation between **information** (isolated units of knowledge that is usually sought after in quizzes) and **knowledge systems** (connected units of knowledge integrated into the system) is crucial for our understanding of the process of acquiring experience and usable knowledge. This process of acquiring integrated and conceptual knowledge (unlike mere information) guarantees understanding and profound thinking, and thus eliminates the phenomena characterised by the term "shallow".

When considering the **general and fundamental effects** of digital media, one must point out two aspects in which these effects manifest themselves. The first relates to cultural media as **extensions and amplifiers** of individual human capabilities in the manner that McLuhan and Vygotsky talked about (we can remind the reader of Vygotsky's words that using the media created by culture "enhances and infinitely expands the possibilities of action", (Vygotsky, 1997, p. 87)). In these times marked by an explosion of digital media, it has already become clear how dramatically these theoretical assumptions are being confirmed: examples include the colossal expansion of individual memory in the form of the internet and strong databases, and the exceptional speed of computing by big computers that has enabled many technical and technological accomplishments (it suffices to simply remind oneself of all the things we need to execute cosmic flights or to guarantee the functioning of all those smart devices or everything that we can glimpse under the term artificial intelligence, namely the complex systems of algorithms).

Much less is known about, and also represents a lesser focus of research, the other side of digital media. This other side relates to **the risks presented by digital media generally.** Here we will only remind ourselves of everything that underlines the term **virtual reality**, where we are actually dealing with creating a parallel world that presents itself to people as a new reality that they inhabit and that is home to many human activities. However, the possibility of creating another reality is at the core of the symbolic function of man (Ivić, 2015). This possibility of constructing symbolic realities and systems is enabled by the emergence of the first symbols in anthropogenesis and ontogenesis. Printed media, based on this symbolic function, has already created an enormous parallel symbolic reality in the shape of all of those "symbolic forms" that determine the lives of men. It should suffice to mention the entire virtual (symbolical) reality created by literature (first as oral literature, that in the form of rare handwritten books and, at the end, in the explosive development of fictive reality in mass printed media). Digital media has brought the human ability of developing fictional reality to a paroxysm. Today we are still a long way from understanding the serious consequences that this creation of symbolic virtual realities in the digital media will have, how it will determine the life of present and future generations that will – from their early years – be growing up both in these virtual realities as well as in physical and socially-cultural realities.

The younger generations spend a great amount of time living in virtual realities, leaving less and less time for life in the real world and for establishing real relationships with people. It is hard to predict the long-term effects of such separation from real life. Clearly, distinguishing the virtual (fictional, symbolical) and the real is of crucial importance, since it is the condition of psychological normality. Today, virtual reality - created by digital media - is perceptually so convincing that it hinders in making this distinction. This can lead to confusing the real and the virtual, especially in certain groups of the population (e.g., psychologically unstable people).

How important the distinction between the real and the fictional (as simply a different term for virtual) is for normality, is demonstrated by the normal development in human ontogenesis. At the age of two, with the first appearance of symbolic tools (such as first forms of symbolic/pretend play, or when one pretends to sleep), the child gives clear signals to the adult that all this is pretence and not reality (with a roguish grin, making sure the adult follows his or her activities (Ivić, 2015)).

As Vygotsky already knew in his time, culturally-psychological tools (like media) primarily have a retroactive effect on the organisation of psychic life. This contrasts with tools for the cultivation of nature that have changed

the nature of man's working operations through history as they were perfected.

Research has already been conducted that concerns the ways in which digital media changes some **cognitive processes**, for example the nature of reading and understanding what was read (remember the subtitle of Carr's book: How the internet changes the way we think, read and remember; or remember the phenomena of the reading brain (or the typographic man); or the phenomena of the "distracted mind" (Gazzeley & Rosen, 2016)).

Here, we will only mention some of the research that relates to social and emotional relationships, and warn about the risks for the development of human relationships (Turkle, 2011, 2015). According to this pioneering research, there are important risks for the development of the human capability for face-to-face social interactions and real conversations (which leads to the "alone together" paradox, that is to loneliness in a time when »social networks« blossom). One of the biggest victims of long-term exposure to digital media is the loss of our capacity to empathise, which is one of the most characteristic features formed in the course of human evolution and is tightly connected to the development of capabilities for the "theory of mind". The theory of mind is a specifically socially-cognitive capability of humans that consists of the ability to recognise other people as intentional beings and enables us to "read" (mindreading) their mental states (thoughts, feelings, beliefs, intentions, attitudes). This is the capacity, developed around the age of two in ontogenesis, that underlies man's symbolic capacity, that is the capacity to create symbols, symbolic systems and symbolic realities (Ivić, 2015). Significant scientific findings (Baio et al., 2014) demonstrate that one of the sources of autism is actually the absence of this capacity to empathise and the capacity for the theory of mind. Related to this, it is of great concern that there is an inexplicable rise in the number of youths with autism in the US: a 254% increase from 2000 to 2014!). Is it possible that there is a connection between the increased use of different digital devices (in the community, by parents and by children) and the increase in the number of people with autism (for example, in the sense that people with a fragile genetical basis could develop affective relations and human relationships in normal conditions and would not have autism but, when these relationships are disturbed, some forms of autism can appear)?

It is terrifying to think about the potential changes in human relationships if the capacity to empathise would seriously be questioned as a result of an increased exposure to digital media and virtual reality.

Printed and digital textbooks

Findings on the nature of digital media are especially important for the issues that concern us in the present – issues relating to educational achievements when using printed or digital textbooks. Digital textbooks are of course only a part of the digital environment. Using and reading digital textbooks differs from reading on the internet, since there are less factors that distract the reading process. However, as a digital medium, digital textbooks also have some common characteristics with other digital tools and some of the findings of the above-mentioned analyses apply to them too.

There is a variety of types of digital textbooks depending on which of the essential features of digital media they offer. The most complex version of digital textbooks is the one that has the greatest number of digital characteristics: **the possibility of inserting new content into a digital textbook, interactivity, multimedia, using hypertext/hypermedia (hyperlinks), connections to other digital sources, the possibility of creating simulations and animations** (e.g., simulations of micro processes or phenomena that cannot be seen with a bare eye), and **all of this interrupts the linearity in the process of receiving information and enables different forms of connecting information** (from different fields, from contents in the programmes at different educational levels), **the possibility of personalising learning (including the determination of individual paths of moving through the text), the possibility to answer questions and solve assignments and get quick feedback on success in answering, the possibility to compare your achievement to certain norms.** All of these are important characteristics of digital media and could serve as valuable means of supporting the learning process. There are great opportunities for enabling a better understanding of materials if the users of digital textbooks could, for example, see a computer reconstruction of dinosaurs, or the building of Egyptian pyramids, or the process of plant growth from seed to maturity, or the simulation of chemical processes in which different colours would represent different chemical substances, or an animated presentation of the functioning of volcanoes, or quickly finding the meaning of a term, or finding a term and its description that is only mentioned in the textbook in an encyclopaedia, or getting feedback on learning success in light of further progress in learning. In principle, all of these possibilities of digital media create the opportunity for an active relationship with the contents to be acquired, they create a basis for learning as a form of research – guided by the teacher in a digital classroom or other similar research. There are few textbooks in the world, let alone in our country, that make use of all of these possibilities. We could even talk about phases in the development of digital textbooks

depending on which digital tools are built into them, from free **pdf** versions of texts, to textbooks that are close to using almost all of these tools in almost every chapter.

However, inasmuch as digital textbooks can significantly contribute to the learning process if the possibilities of the digital media are predominantly adequately used, digital textbooks also share the destiny of other digital tools with regards to the negative effects that appear due to the nature of every digital medium. The basic negative effects that could hamper efficient learning from digital textbooks are the same as those we have already mentioned when discussing other digital tools. Above all, we are talking about the effects related to **"disruptive technologies"** that are extremely difficult to avoid when creating a true digital textbook. Namely, technological disruption occurs every time a textbook uses image, audio or video inserts, since this causes an interruption in reading and eventually leads to losing the main thread of the text. The same happens in situations when you click on a certain part of the text (e.g. when you need to look for an explanation of an unknown word or are trying to expand an idea), or when you need to choose a tool to interact with the text (highlighting, underlining, note taking, erasing errors etc.), or encounter technical problems when navigating through a textbook etc. These interruptions lead to a loss of focus (especially when the content that distracts our attention is not directly or adequately connected to the course of ideas in the text), and to interruptions in the process of translating short-term memory into long-term memory and to shallow reading, which we have already discussed.

Another big problem for the creators of digital textbooks is how to avoid **cognitive overload** that appears when using digital textbooks, because different phases of using digital textbooks create moments when students have to make quick decisions (e.g. whether to use a certain insert or not, to react to the text by using one of the tools and which one to use, to use a dictionary when encountering an unknown word etc.); when student aim to complete the tasks posed by the text (answering questions, making notes etc.). These situations of cognitive overload also lead to disturbing the process of understanding. Especially significant problems in this process of understanding the message of the text occur when students' attention shifts away from the textbook to other digital tools (following the teacher in the digital classroom, public or hidden checking of messages on smartphones, reading the news etc.). Taken together, all these possible interruptions when using digital textbooks create the illusion that the information that has been received (individual isolated information) has led to true knowledge, that is, to understanding the basic ideas of a certain lesson and to integrating these ideas with existing knowledge, and consequently to

constructing conceptual knowledge. It is a fact that the internet contains a mass of individual, isolated information but not conceptual knowledge that can and should be constructed by each user of these digital tools – not by memorising this information but by fully engaging one's thinking.

When creating digital textbooks, the publishers and authors (there should be authoring teams) find themselves face to face with an enormous challenge to **use all of the potential of digital media in order to support and help gain an understanding of the content, and to maximally reduce the serious risks that digital media poses by its very nature for this process of understanding, memorising and mental engagement.** Here we only talk about reducing the risks and not about their full elimination, since some of them are inherent to digital media.

Solving these difficult *aporias* should also contribute to achieving a long-term goal in using digital media (that we are still far removed from attaining), that goal being **forming digital competences and the digital literacy of students** that will enable young generations to adequately use other digital tools as well as other digital media, in the same way that the printed media contribute in establishing a culture of reading. **Quality digital textbooks and competent management on the side of teachers** (who for now, unfortunately, do not have adequately formed digital competences and should be specifically equipped for this task) **should function as a counterweight to self-made "wild" navigation through digital media.** Some of these demanding issues should be solved by defining good **quality standards specific to digital textbooks.**

Alongside the above sketched theoretical frameworks for understanding the nature of digital media and their effects (including the effects of digital textbooks) there is another basis that could help us gain a specific understanding of the nature and effects of digital media – **our long-standing experience with printed textbooks.** Although some passionate proponents of rich informatics tools will say that textbooks are not even necessary in this digital age since all information can be found on the internet, "on google" – this represents only an extreme version of the illusion that a set of information is identical to knowledge. This other basis rests on the fact that a **digital textbook is – a textbook**, which implies that it has to comply with the highest standards of quality textbooks while also acknowledging and respecting the specifics of digital media. There is even more variety when talking about printed textbooks and there exists a long historical process of their development – from a mere text which contains the school programme[5], through to textbooks that also contain

5   The english word textbook only speaks of a text while the word *udžbenik* (derived from *učiti se* – to learn) found in Serbian and some other slavic languages, speaks also of the fundamental function of this specific book.

different structural components (images, tables, figures, maps, atlases etc.), to textbooks that also include digital components (CDs, DVDs).

We have already said that only the best versions of digital and printed textbooks should be compared, that is, textbooks that make optimal use of the media in question. Such digital textbooks do not yet exist, since there has not yet been enough time to create them. We have, however, much more experience with printed textbooks. There is a huge amount of research on their contents, structure and the structural components that comprise them. There also exists the production of very good printed textbooks.[6] Many countries have defined textbook quality standards as a mechanism for developing their quality (in Serbia these standards are tragically low, despite the fact that we have enough expert knowledge to create the best possible textbooks (see Pešikan, 2016)). Here, it is neither possible nor necessary to present the results of all of these experience with, and analyses of, printed textbooks. Instead, we will only present a highly summarised core by relying mostly on a book that contains a synthesis of these findings (Ivić, Pešikan, & Antić, 2008).

The textbook is a **specific book** that is first and foremost determined by its function, – it presents a fundamental resource for learning and is intended for a clearly defined circle of users, for a defined level of education, age and field of education. In this way it is distinguished from other genres of books that are related to it, like encyclopaedias, scientific monographies, popular science editions etc. In terms of contents, one of its specific characteristics is that it contains **systems of knowledge from different fields of knowledge** (which does not exclude textbooks in some interdisciplinary fields, especially in higher education) **which are adapted to the developmental and age possibilities of the intended audience.** This organisation of knowledge follows the lines of the so-called school subjects and has to be encompassed in school programmes. It presents the essence of institutional education in schools and it is in these aspects that school knowledge differs from episodic life experiences and partial information from the internet, or from any other sporadic source.

There are clearly defined textbook quality standards that pertain precisely to contents. In this respect, most digital textbooks that have been created so far are deficient, since they are often more focused on creating attractive multimedia components, aligning themselves with the apparent greater interest of children and youngsters for such digital content and for using digital tools resembling video games. There is a common illusion among passionate

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6   They can be found for example in the library of the international institute for textbooks, the Georg Eckert Institute in Braunschweig, Germany. The institute is also the official Unesco institute for textbooks. It contains more than 200.000 textbooks from all over the world.

proponents of digital textbooks that children learn easily and quickly in this way, despite the fact that this is not grounded in any research or evidence.

All structural components of the textbook (the main authored text, the iconic sources, dictionaries of unknown words etc.) and all organisational units that facilitate navigating through the textbook (like clear contents, chapters and subchapters, titles and subtitles, the graphical organisation of the text - like highlighted text, text in frames etc.) are defined based on the function and the **audience** (that is for whom the textbook is intended). But the basic demand any good textbook must meet is **that all components and organisational units (chapters, lessons) must systematically lead to achieving learning goals from the textbook; that the textbook as a whole and all its components must not disperse attention but enable it by concentrating on the main ideas of the text, since this is the only way to acquire systems (or parts of systems) of knowledge that are contained in long-term memory and to enable connecting prior knowledge to new findings that will be acquired at the following levels.**

There is a great number of quality standards that relate to this organisation of the entire textbook. These are textbook quality standards that relate to the didactic design of the textbook and their adaptation to the developmental and age-related capabilities of students. When using multimedia components, the existing digital textbooks are often very well adapted to both (sometimes they even fall beneath the level of students since they simplify and banalize the multimedia components with the aim of increasing attractiveness), **but suffer from significant inadequacies in terms of didactic design that is due precisely to the nature of digital media that often leads to a distracted mind, to interruptions in the development of the basic threads of content, to information and cognitive overload – and thus disturb the construction of a system of knowledge.**

A great progress in improving the quality of textbooks was the consequence of introducing one of the most characteristic features of textbooks: meaningful and cognitively challenging questions, assignments and tasks for students' independent work. As long as textbooks contained only the explanations of materials prescribed by school programmes, learning was more or less reduced to memorising text (sometimes also learning it by heart), especially if teachers also adopted such approaches to learning. Questions, assignments and tasks for students' independent work, when constructed with consideration and when the teacher supports them, can mentally and emotionally encourage independent work, thinking about the materials, critical thinking and thinking about the possible applications of the knowledge that is being acquired. This contributes to achieving the aims of school learning that cannot be achieved simply by working on a text that is a mere explanation of material (just as a lecture in a class looks

like), and these are: developing independence in learning and work, developing problem-solving capabilities, the ability to connect materials from different fields, connecting materials to students' prior knowledge and experiences, developing the ability to apply knowledge (in part this is also examined by PISA to internationally examine school learning outcomes). Questions and assignments for students in the existing (our) digital textbooks are the worst component of these textbooks, since they resort to forms of assignments that are most easily provided in a digital environment and are easily evaluated with their results being easily statistically analysed. In most cases we are talking about questions and assignments of a reproductive nature in the form of multiple-choice answers.

A special issue relates to the way students **use textbooks.** The ways in which they use them mostly depend on teachers' attitudes towards a textbook: if teachers view textbooks as mere summarisations of prescribed school programmes and neglect all the components of the textbook that aim to lead students towards actively relating to the materials (underlining text, asking questions about contents that were not understood, or connecting knowledge in the text with life and out of school experiences etc.), then the students will also ignore these extremely important components of the textbooks. In one significant empirical research study conducted on this issue (Antić, 2014), it has been established that there are no differences in learning outcomes when learning from textbooks of different qualities because the students, under the influence of their teachers' relationships towards textbooks, don't use textbook components that activate thinking because their teachers do not do so either. The study demonstrates that the way of using textbooks is strongly connected to the way teachers work. For example, students even perceived explanations of unknown words that can be found on the page border and that are supposed to help them understand the text as a disturbance, because learning is reduced to memorising the main text of the lesson (Antić, 2014). These insights imply that one of the great challenges in introducing digital textbooks to schools will be the way in which teachers use them, and how they guide students in using textbooks. Superficial and insufficient teacher training (and most teachers possessing less competences in the digital field than students) will be a huge obstacle to introducing digital textbooks in our schools.

Empirical research on the process of reading and understanding text

Alongside the general theoretical framework for examining the facts surrounding the nature of media (which was already presented with regards to

printed media) and lessons from printed media development, there is a more direct way of assessing the educational effects of digital textbooks. **What we have in mind is the empirical research on the effects of digital media itself or comparative research of the effects of printed and digital media.** There is little research for now on the outcomes of learning from printed or digital media.

For the purpose of this paper, it will suffice to demonstrate some results of a very rigorous analysis of empirical research focusing on the processes of reading and understanding printed and digital texts (Singer & Alexander, 2017). The authors have created an overview of almost all such research that has been produced in the past 25 years (from 1992 to 2017).

The authors have conducted a very rigorous and scrupulous analysis and accomplished the following: they have systematically examined all of the relevant journals and authors, and have compiled 853 pieces of research; they have defined clearly the selection criteria for the works analysed (the work had to include reading printed and digital text, the research had to be empirical, the research did not solely concern the attitudes and experience of the reader but must include objective tests for assessing the understanding of the text read).

Based on this criteria, 36 works have been chosen for a detailed analysis in light of aspects concerning a set of parameters, such as: is a definition of the reading process provided; is reading a single text or several texts analysed; is there data on the length and genre of the text; which data about the participants was gathered (age, school level, prior knowledge on the contents of the text etc.). The authors have also analysed the changes that have occurred in relation to similar research in the past 25 years (at this point we are leaving these conclusions aside).

To understand the findings of this research it is important to note that digital reading in the works analysed referred to **reading on digital devices and reading text that contained hyperlinks (hypertext or hypermedia)**. In this sense, the authors distinguish **digital reading** (in the sense of the previous sentence) from reading digital contents (for example reading on the internet or reading contents that possess all or most of the characteristics of digital media such as: multimedia, simulation, animation, linking to other sources of information, personalisation etc.). Thus, digital reading in the works analysed is reading texts that lack some of the crucial characteristics of digital media (e.g. multimedia, constant connectedness to other sources of information etc.).

At the end of this meticulous analysis, the authors came to some significant conclusions: reading printed and digital texts gives the same results if we monitor the readers' understanding of the basic theme of the text and their ability to find individual information in the text; reading printed texts provides better understanding when reading longer texts (the authors distinguish a short

text as being up to 500 words – approximately one page – and longer texts as more than 500 words); printed media results in deeper understanding of the texts if we apply tests of understanding that seek to measure the level of understanding the whole message of the text, or if we examine whether the readers go beyond the frame of the text and evaluate it or apply critical thought to it; the process of understanding the text is hampered if readers are required to navigate through the text; understanding the text depends on individual variables (age, school level, the assignment they get prior to reading (e.g. to memorise the read content; to answer questions after reading etc.)).

Despite the fact that the works analysed focused only on digital reading as reading continuous text with the possibility to establish hyperlinks (and without any other digital media characteristics), this analysis of well-chosen empirical research clearly demonstrates the potential negative aspects of digital media that must be overcome in the future development of these textbooks. These include issues such as: **reading and understanding digital texts brings significant issues when reading longer and more complex texts (continuous texts, for example explicative text and not descriptive text), or when we aim to achieve a deeper level understanding (for example the levels 6 and 7 in reading proficiency as measured by PISA).**

It is also not hard to see that these preliminary results of empirical research are mainly in line with the theory of digital media that indicates some essential issues of the media: that it is a medium characterised by "interruption technology", a "distracted mind"; that it leads to cognitive overload that hampers achieving deeper understanding of what is being read, and that it has some serious repercussions for the functional organisation of the human brain that manifests itself in all areas of life.

One of the goals of this overview of empirical research is to gain a more precise definition of the conditions that need to be met by further research. In this sense, the authors conclude that it is of utter importance to precisely define the following : what is the aim of reading a certain text (digital or printed); what is the nature of the text and what are its effects (continuous or discontinuous, multimedia or non-multimedia); genre of text (narrative, explicative, descriptive etc.); a more precise definition of the length of the text; and, especially, the interaction of the text genre and length, the general context of reading (school, exams, research), and students' individual characteristics (capabilities, level of knowledge, values etc.).[7]

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7   With regard to the nature of the text and profficiency in understanding the text some authors use (unfortunanely not completely) the clasification of texts as it is given in the PISA definition – there are 7 levels of proficiency to assess reading: from finding isolated indiviual information in the text to the level of evalution and critical attitude towards the contents and structure of the text (OECD, 2017).

It is probable that we will see increasingly more empirical research that will achieve this level of precision and it is only research of this kind that can give us trustworthy insights on the educational efficiency of the best versions of printed and digital textbooks. This research must focus rigorously on defining **which categories of educational achievements can be attained with the help of one or the other of the types of textbooks. For example, which type of textbook is better for the following educational outcomes: finding basic information; gaining insight on the basic messages of the entire text; understanding the relationships among parts of a text; connecting text content to readers' life experience; forming conceptual knowledge; forming attitudes and values; critical analysis and evaluation of text; analysis of the relationship between reading and the purpose of reading a certain text.**

It is quite certain that reading digital contents and digital textbooks will be perfected. However, considering that digital textbooks are a relative novelty, publishers are more focused on producing textbooks that give the impression of being truly digital and attractive for children, but do not consider the issues discussed above that should be dealt with when producing digital textbooks. It is very likely that publishers do not have a complete insight on how problematic it is to adequately use powerful digital tools and yet avoid the significant issues that digital media creates by its nature in the process of constructing systems of knowledge, namely long-lasting and usable knowledge. This is probably the main reason why the "digital revolution" in education has not yet occurred and why the impact of digital media on education, according to world's leading promoters of the digital revolution, has thus far remained at the level of rhetorical claims about it creating a radical change in learning and teaching (Pešikan, 2016).

We can get some useful insights on digital textbooks from the experience of those countries that have gone further in the general process of digitalisation and mass production of digital textbooks.

South Korea has probably gone the furthest in this development. It is a big producer of digital devices and one of the leading countries in digitally revolutionising all spheres of life, and has progressed immensely in creating a general digital environment for its whole society. Its inhabitants massively use digital devices and there are also strong financial incentives for digitalisation in education.

With regard to digital textbooks, in 2007 the government of South Korea came to the decision that by 2015 the nation would start using digital textbooks at all levels of pre-tertiary education in all school subjects (this decision, perhaps hasty, was probably also influenced by the interests of a strong industry of digital devices). This is why it is important to study the experience of South Korea in this area.

Here are some insights from the experience of South Korea: the process of introducing digital textbooks continues but has to be constantly improved; the plan to shift to digital textbooks only in 2015 was not achieved, which is why a new process of introducing these textbooks after 2020 applies to some subjects and levels; printed textbooks remain alongside digital textbooks; there are only printed textbooks in the first two years of schooling; digital textbooks for different fields of knowledge require different design (social sciences, maths, natural sciences); digital textbooks have different effects on different parts of the population (e.g. children from rural or urban areas, children with different capabilities).

The basic reasons for the change in politics in the field of digital media (Koreabizwire, 2018) aregiving up the illusion that digitalisation in itself will bring about progress in quality education; frequent use of digital media can negatively affect students' health, about 12 % of children between 5 and 9 years have developed a true addiction to digital media; the educational effects of using digital textbooks are not really as big as they appear to be. Based on this, some notable American newspapers have concluded that the core message from the South Korean experience is that digitalisation has to be implemented with more consideration.

Conclusion

A digital revolution is taking place all over the world. Digitalisation in education is a reality of contemporary education and will surely develop further since there is no sign of giving up on digital media in education.

In the following years, with new generations of digital textbooks, we will also have more solid evidence on what kinds of educational outcomes can be achieved with the help of digital textbooks. A particularly big problem that requires creative solutions concerns using printed and digital textbooks for achieving specific educational aims and outcomes according to the advantages of each type of textbook.

One of the most promising approaches is creating hybrids of printed and digital textbooks based on the fundamental principle to take advantage of each of the media forms to achieve learning objectives where the particular medium, because of its characteristics, takes precedence. While the principle is clear, actualising them in practice appears to be extremely difficult (which has been demonstrated with the already existing examples of these textbooks).

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